HEALTH

AS AFFECTED BY LAWS

GOVERNING LOCAL AIR-CURRENTS.

A NEW DISCOVERY.

SANITARY TOPOGRAPHY.

BY JAMES FORD, M. D. (U. S. SURGEON).

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HEALTH AS AFFECTED BY LAWS GOVERNING LOCAL AIR-CURRENTS. (A NEW DISCOVERY.)

PRELIMINARY OBSERVATIONS—HYGIENIC CONDITIONS APPARENT—ATMOSPHERIC INFLUENCES—HISTORY OF THE DISCOVERY, AND THE INVESTIGATIONS FOLLOWING IT—AIR CURRENTS GOVERNED BY LAW—ILLUSTRATIVE DIAGRAMS, AND ACCOMPANYING EXPLANATIONS—ACTIVITIES CAUSED BY THE SUN—THE EFFECT IN DIFFERENT LOCALITIES—MALARIA—EXAMPLES OF THE REMOVAL OF RESIDENCES AS SANITARY SUGGESTIONS, AND THE RESULTS—AIR MOVEMENTS ON LEVEL LANDS—PECULIAR AIR MOVEMENTS—PATHOTOPIA, WHERE NOT TO BUILD A HOUSE—HYGETOPIA, OR WHERE TO BUILD A HOUSE—FACTS ILLUSTRATIVE OF OTHER AIR-CURRENTS—CONCLUSION.

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These pages were written for the people and recently published in the History of Wabash County, Indiana.

SANITARY TOPOGRAPHY.

PRELIMINARY OBSERVATIONS.

The object of the following pages is to make known an original discovery in sanitary science of great value to the people.

"Hygiene is the art of preserving health. It aims at rendering growth more perfect, decay less repaid, life more vigorous, death more remote."—*Parks.*

§ 1. Local currents * of air are governed by law, and always move under similar circumstances, in the same direction.

§ 2. The air, in dry valleys, in summer and fall seasons is warmer, hence lighter, than that of adjacent high lands, and that immediately over the valley.

§ 3. The cool air of the high lands underruns the warmer, higher atmosphere of the valley; the lighter flows up over the cooler on the elevated lands, cools off, settles down and runs back into the valley; thus forming a revolving elliptical ring (§ 8), which carries and distributes the heat, malaria and germs of disease of the valley on the high lands. These movements take place alike and at the same time on both sides of the valley, and continue at this place [Wabash], until 11 o'clock P. M

§ 4. The air in the valley, by the loss of heat, shrinks in volume, causing a sag in the upper air, which, by its dynamic force, continues with an accelerated motion, subtending both the other currents. It settles down in a wedge shaped body, with its apex over the center of the valley, reverses both the lateral currents, and when its point is heated by the soil it parts in the middle and runs upon the hillside on the elevated lands. These movements continue until the sun's rays in the morning change them.

§ 5. All these air currents described above form a great pneumatic engine to carry the heat and vapor from the heated low lands, and to distribute them over the high grounds and hills. If it be in a valley, the machine moves up at the rate of from one to four miles per hour. Malaria and the germs of dis-

* Local currents are those movements of air confined to the surface of the earth, and do not extend usually, beyond the immediate locality, and are caused by the differences of temperature of hills and valleys, of wet and dry lands, of prairies, adjacent groves, and do not include winds that move steadily in one direction.

ease are carried and distributed over the country wherever these air currents move.

§ 6. The question of Health or Disease in any locality, may be determined within 100 feet, *a priori*, by understanding the topography of the locality, as well in prairies as among the hills and valleys.

§ 7. The place for orchards, vineyards and tender plants may be as easily settled as the questions of health or disease. They should not usually be placed near the dwelling house.

These observations and experiments were always made of still nights. During the day time the sun's rays render the atmosphere so unsteady that accurate observations cannot be made in this direction.

§ 8. By understanding the foregoing propositions, any person of ordinary intelligence may select a site for a residence, free from malaria and the germs of disease, if such place can be found on his land.

For the benefit of residents, the names of places and persons are given in full in the following pages.

DISCOVERY, AND SUBSEQUENT INVESTIGATIONS.

§ 9. After a hard day's ride among the sick on Paw-Paw, I returned home weary and hungry, neither myself nor horse having eaten anything since morning. The fall rains had rendered the roads almost impassable. The roads at this time were mere paths marked out on trees and bushes, and lay, principally, along the Indian trails and were difficult to follow in the night. This road passed through a dense forest of some seven miles, without a house, but my trusty horse brought me home at 8 o'clock P. M. This occurred on the 7th day of October, 1843.

§ 10. The people, at this juncture, had plenty to eat, but were poorly clad; the climate was damp and the country was full of malaria. Their houses were poor, and the incessant labor required to clear away the forest and raise their crops was a heavy tax on their vital forces. Thus they suffered from ague and all that class of diseases arising from over work, dampness and malaria. We had more sickness this fall than had occurred in the two previous years. Cutting away the timber and turning up the virgin soil to the action of light and heat, seemed to increase greatly the germs of disease. The water level was too high.

Two messengers had come and gone, one leaving word to go to Jonathan Keller's, the other to go to Jacob Ungers, and a third messenger, still in waiting, desired me to go and see John Lamaroux, living four miles west. All these people had a form of bilious remitting fever, and it was desirable to prescribe for them at as early a period as possible, to "cut short" the disease, or, at any rate, to modify its character so that the lives of the patients should not be jeopardized. The night was cold, hazy and dark; neither moon nor stars were visible; the air did not move, and a death shade seemed to have settled over the face of

nature. Weary and care-worn, we plodded along four miles to the ravine of Kintner's Creek and could not tell how we got there. But, while my horse was drinking in the stream, a volume of warm air struck my face, passing gently up the ravine, northward; the odor of decaying vegetation and animal matter from the bed of the Wabash River—a mile and a half away—was freighted upon it. The hills on each side of this creek are from ninety to one hundred feet high, and the valley itself probably forty rods wide. The heated air filled this ravine from hill to hill, but its depth could not have been more than twenty feet, as it did not rise higher than this on the hill sides. It was now 11 o'clock P. M., and the heated air had just reached this point on its northward course, for it was not felt when the horse first entered the stream.

§ 11. Mr. Lamaroux lived on the opposite side of the creek in the valley, and of course his dwelling was submerged in the warm, stinking atmosphere. After prescribing for him, the next point lay one-half mile south and one and a half miles west. This brought us to Jonathan Keller's residence, on the hill, one mile north of the Wabash River—a malarial district. Two patients were prescribed for here. From this point we retraced the road back eastward, one and a half miles, and then turning south we crossed the stream and entered the valley of Mill Creek. The river bottom here is nearly one mile wide, bounded by hills ninety to one hundred feet high. In the middle of this bottom, the same heated air laden with similar noxious odors was found passing gently eastward up the river.

These facts were observed, but the exhausted body and sluggish brain could not give them more than a passing thought. The valley of Mill Creek, like that of Kintner's Creek, a stream coming in from the south, has cut out the Silurian rock nearly one hundred feet, and a mile back from the river bottom. Jacob Unger lives in this valley, one and a half miles south of the river. While traveling up this stream, the odor was observable, but the air appeared to be entirely still; but it was soon found that the horse was traveling as fast as the air, about four miles an hour.

While the horse was being tied to the fence, the question sprang into my mind, per se, apparently, "How is this? Here are three currents of air proceeding from a central point along three of the cardinal bearings of the compass;" but no answer came to this recondite question. The mind could not grasp it; the brain refused to evolve an idea concerning it. Yet, like Banquo's Ghost, the question "would not down," but haunted me for years, until many of its knotty points had been unraveled. Mr. U.'s family were prescribed for and we took the Indian trail on the south side of the Wabash River, for home, and reached that desirable place at the break of day. "Labor omnia vincit."

AIR CURRENTS GOVERNED BY LAW.

§ 12. Were these air currents governed by law, in their movements, or were they accidental? (§ 17, 33).

It was soon discovered that after the sun had set, the ravines and narrow valleys cooled down to the temperature of the air on the highlands, long before the larger river valley cooled; consequently, a stream of cooler, denser air ran down them and seemed to under-run the warmer air in the river bottom, some time before it flowed over the brows of the hills along the river sides. Air always moves in the direction of the least resistance, and in this way heat is distributed over the face of the country and the valleys are cooled.

§ 13. The small valleys subserve the purpose of viaducts to carry cool air into the river bottom; but, when an equilibrium is established, they act as a chimney to carry it and the fog back upon the high lands on both sides of the river.

§ 14. "Heat and cold," says F. M. Maury, "the early and later rains, clouds and sunshine, are not, we may depend upon it, distributed over the earth by chance. They are distributed in obedience to laws that are as certain and as sure in their operations as the seasons in their rounds."

"From the heat of summer, our winds are derived. We live at the bottom of an aerial ocean which is to a remarkable degree permeable to the sun's rays, and is but little disturbed by their direct action. But these rays, when they fall upon the earth, heat its surface; the air in contact with the surface, shares its heat, is expanded and ascends into the upper regions of the atmosphere. Heat is a mode of motion"—*Tyndal.*

"The ready expansibility of air by heat gives rise to the phenomena of winds."—*Fround's Chemistry.*

§ 15. Open the door between a cool and a hot room; hold a lighted taper in the middle, the blaze stands vertical; elevate the taper, and the blaze is drawn in the cool room; lower it to the floor, and the flame is flared outward. This experiment proves that the cooler air is heavier than the warmer air. This law, imposed by the Creator himself, on all physical substances, governs the lightest breeze as well as the hurricane and the cyclone which mock the Seaman's strength and set at nought his skill. The heated air takes the place of the cool.

§ 16. The sun's heat in summer penetrates the earth by induction to the depth of forty to ninety feet, depending on the moisture and the looseness or compactness of the soil.

The facts stated above are the results of observations made during the autumn and spring of 1843 and 1844. No attempt, as yet, had been made to demonstrate, by instruments, the truth of these theories and statements. To the observant philospher who contemplates the agents of nature, as he sees them at work on the face of our planet, no expression uttered or act performed by them is without meaning. The heat and cold, the frost and vapor, the density and tenuity, the inertia and motion of air, each and all may be regarded as the exponent of certain physical conditions, and therefore, represent the language she selects to make known her laws. To assist others to understand this lan-

guage and to correctly interpret these laws is the object we now have in hand.

§ 17. In the fall of 1844, with a box of matches and a chunk of dry, rotten wood, we started out at 8 o'clock P. M. to make observations of air-currents on the hills and in the valleys of the Wabash River. The valley of Charley's Creek was first visited. [See map]. The smoke from the rotten wood was our first vane. The smoke moved toward the river, and as we were walking so as to keep it above head—the smoke ascending in a vertical column—the rate of motion could be pretty accurately determined. The current on the high lands was in the same direction. In a few minutes a fleet horse placed the vane on the south side of the Wabash River, in the valley of Treaty Creek, a mile and a half away. Here the air moved in an opposite direction, running into the valley from both sides, slowly indeed, but surely. In this I was disappointed. It had been supposed that the subtending, central current would force the air of the valley upon the hills, as explained above, but it did not do it. These observations were repeated every hour, with nearly the same result, up to 11 o'clock, P. M. (§ 20). At this time the air currents stopped. The atmosphere was agitated, and within the space of three minutes, smoke from the torch moved in an opposite direction. Now it was evident that the downward current, by its density and by its dynamic force, had checked the momentum of those lateral currents and turned them in an opposite direction up the hillsides and ravines. (§ 19).

§ 18. This rough experiment was made for the reason that philosophical instruments could not be had this side of New York, yet it showed that many factors entered into these movements, and that my hypothesis was too simple to explain all these complicated forces. Finally, the following outfit was procured, viz.: One mercury barometer, two thermometers, one plain and one wet bulb, four vanes (these last the writer constructed), one pocket compass, one watch, one note book, one horse, saddle and bridle, one box of lucifer matches and one lantern. The barometer could not be carried through the bushes at night and was not used. The stations visited each night were from four to six, and often miles apart. From dark to daylight, the grand rounds were made every three hours. Notes were taken at each station of the time, temperature and of the direction of the winds, with the direction of the clouds, if there were any. These experiments were repeated many times every autumn for several years, with nearly the same results. The reader will have to take my statements, or otherwise repeat the experiments himself, as the space alloted, to me in this volume will not contain them. The field of these discoveries is too large for any one mind to thoroughly cultivate; with the writer, the sands of life are too nearly run out to prosecute this work further.

If any scientist will take hold of this subject, his knowledge and pleasure will be greatly enhanced to observe nature as she

is, on a gigantic scale unfold her laws, not adverse to, but in harmony with, all her works. A few attacks of bilious fever, a few shakes of ague and the loss of many nights' sleep must not cool his ardor for the prize is at the end of the race.

EXPLANATION—This plate (see plate 1, page 9) is made to show the movement of local currents of air in the Wabash Valley during still nights in summer and autumn.

A B represents a cross-section of the Wabash Valley and hills on each side of the river; also, the stratified rocks that underlie them; R, the bed of the river; C, the canal.

§ 19. The air on the elevated lands, in summer and fall, is cooler than the heated air of the valley, and under-runs it. The heated air at the same time parts in the middle, rises and flows back on the hills, where it cools and then returns to the valley, there to be expanded by another volume of heat. Thus the two currents from two great revolving cylinders, extensive as the valley is long and as wide as both valley and hills—in other words, as wide as the outflowing current extends. E E and D D represent these currents. [See arrows in Plate 1.]

§ 20. These movements, as described above, continue until about 11 o'clock P. M.; then they suddenly stop, when a new factor or dynamic force makes itself manifest. The shrinkage in volume of the heated atmosphere in the valley by the loss of heat causes a sag in the upper air immediately over the valleys, which gravitates until its apex fills the entire depression between the hills.

§ 21. This subtending air movement is represented in Plate 1 by the letters F F F, and the arrows with a cross. The letter F at the top, represents the sag, but the arrows below show the direction the air takes after it reaches the earth in the middle of the valley. The air now in contact with the soil is heated, passes up the side-streams, hollows and on to the hills, as it did in the instance before given, but it does not return from the high lands, as the descending current supplies the outflow. These movements continue until the sun in the morning, or some other disturbing cause, change them.

EXPLANATION.—§ 22. Plate 2, page 10, is a map of fifteen sections of land situated around the city of Wabash. The hills and river, the side streams and the canal, the roads and original surveys of land, are laid down. The name of the owner who occupied the land during the time these observations and experiments were in progress, is written upon it, and especially the location of his first, second and third house is given. A peculiarity in the topography of the country, shown on the east end of this map, touching the healthfulness of the locality, will be described further on.

ACTIVITIES CAUSED BY THE SUN.

1. § 23. We must not fail to recognize the fact that the sun, though only a private in serried hosts of heaven, is in a material

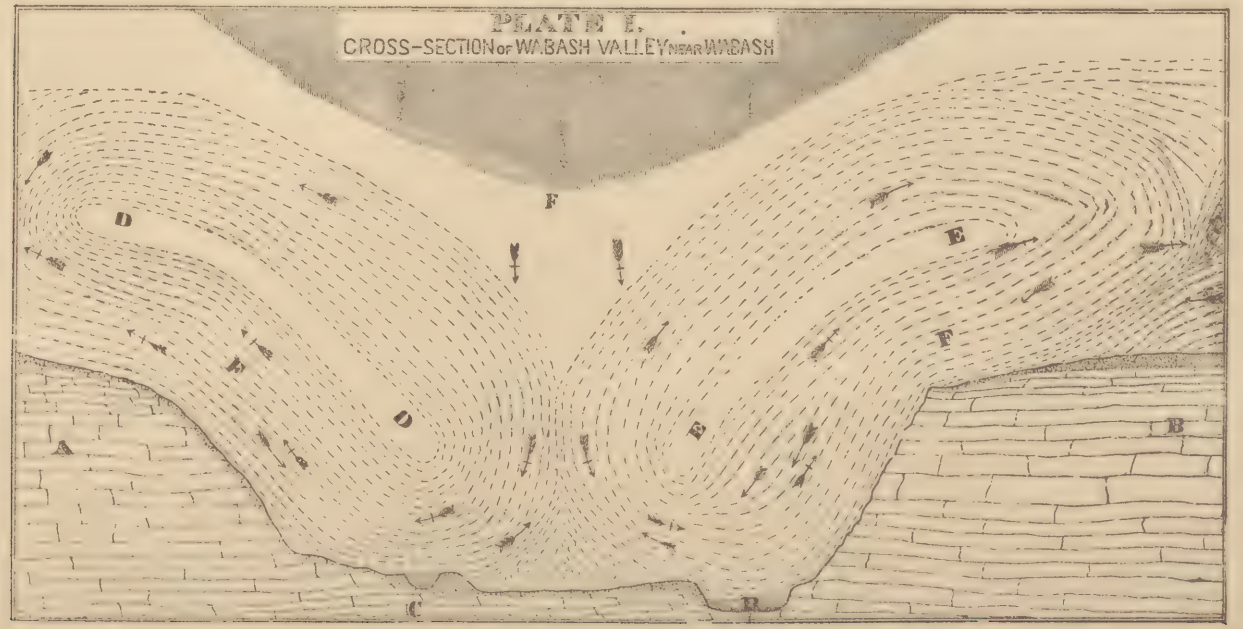
PLATE I.
CROSS-SECTION OF WABASH VALLEY NEAR WABASH
F
D
E
D
E
D
E
F
A
B
C
B


PLATE II.
A PART OF
TOWN 27 N. RANGE 6 E.
WABASH COUNTY IND.
WABASH CITY
Wabash River
Canal
Chippewa Road
Manchester Road
Charly Creek
Helms Creek
Fords Branch
RES. 17
RES. 19
T.W. McClure
Renecer
W. Donalds
T. Ross
H.H. Gillan
J.D. Conner
J.U. Pettit
L. Thomas
S. Mason
N. Chiles
J. Allen
C. Story
D. Helm
Johnson
W.J. Ford
M. Cory
J. Carter
Road
N
S
E
W

sense, so far as terrestrial affairs are concerned, almost absolutely the prime mover of the whole. Cut off his rays for a single month and all energy, whether "mechanical, chemical, or vital," would cease, and the earth herself would crystallize and die.

2. § 24. Since the doctrine of the correlation of forces and the conservation of energy has been comprehended and formulated, it has been an easy task to confirm them by experiment; to trace terrestrial phenomena and the varied classes of energy, one by one, to solar origin.

3. § 25. The raising of water from rivers, lakes and seas, the building up of animal and vegetable organisms, the power of steam, the force of the zephyr, of the storm and of cyclone—are directly, or remotely, all the result of the transformation of the sun's heat into the physical energy. When the sun works, it is by undoing some previous work. If the surface of water is heated by the vertical rays of the sun, vapor flies off in the form of steam. The same power, by the agency of the air, carries it on to the mountains where it is condensed into rain, and now the earth and its inhabitants drink; nature smiles—the sun has finished his work. It may be observed however, that solar energy, while this work was in progress, completely suspended or overpowered the force of gravitation, though millions of tons of water were raised to the top of the mountain in defiance of it, yet by its own gravity, the major part of it ran back to its original fountain.

As solar heat is the prime moving cause of all air currents, some attention must be given to the laws that govern the performance of its work.

4. § 26. Heat seeks an equilibrium in three modes: First, by conduction. This takes place only in solids. Example: Heat one end of a poker, the other end may be cold, but the heat passes up the bar from particle to particle until it produces the same temperature from end to end. The earth's surface is heated in the same manner, from the top downward, but if the ground is wet it will not descend rapidly, as explained at Section 10.

5. § 27. By convection. "This takes place only in liquids and gases. In these, every particle is in turn brought in contact with a portion of the vessel, when the heat is applied, until all have attained the same temperature."—[Pynchon.] Example: This is illustrated by boiling water in a glass tube over a lamp. Throw into the water a small amount of pulverized coloring matter that will not readily dissolve, and apply the heat. The coloring matter will soon begin to move up one side of the tube, while that on the opposite side will run down to take its place. This motion will continue in the tube until every particle in it is heated to the boiling point. The expanded liquid in the tube being lighter bulk for bulk than the cool above, rises up and gives place to the cool below. This revolving motion continues until every particle of water is brought in contact with the bottom of it. These phenomena are illustrated in nature, on a large

scale, in the Gulf Stream and in the Trade-winds (q. v.) as set forth under the head of Local Currents. Forty years ago, very little was known touching these questions.

6. § 28. Radiation.* Heat seeks an equilibrium by radiation, by flying off in straight lines through space, from a hot to a cool body. "It is clear that heat is not transmitted by conduction from particle to particle of the intervening air because the conducting power of air is extremely small."—[Pynchon.] It plays off from a heated body, not in a vertical column as by convection, but equally in all directions, like the radii from the center of a circle." (Idem.)

7. "Radiant heat follows the same laws as radiant light, and its velocity is the same, and they diminish as they recede from the hot body, not in proportion to the distance, but to the squares of the distance." A heated stove, for example, as every one knows, throws off its heat in every direction, from its sides, bottom and top.

8. § 29. When the sun shines simultaneously on land and sea, in the warmer latitudes, the two become unequally heated. This arises from their different absorbing power. As the sun's rays pass through the water from above without obstruction, it is very little heated; thus, of the two, the earth becomes much the warmer. The air over the heated earth, being expanded by heat, rises and overruns the cooler air of the sea, while at the same time the cool air of the sea underruns and takes the place of the heated land-air, thus forming a revolving aerial cylinder of wide dimensions, with its axis lying parallel to the shore. These currents and counter-currents move on from morning until night. After the sun sets, by radiation, both sea and land begin to cool, the latter much more rapidly than the former. When the temperature of the earth sinks lower than that of the ocean, which it usually does early in the morning, the motion of this pneumatic cylinder is reversed, carrying the sea breeze, washed and purified in ocean's bosom, back to land again. At the same time, the land breeze is whirled out freighted with many impurities, living organisms and germs of disease, to undergo an ablution similar to the former. These agencies equalize the temperature of both earth and ocean and render districts otherwise uninhabitable, cool and healthful, and the breezes fill the sails of coasting vessels coming in and those going out, each one-half the time. Who cannot see wisdom, power, and goodness here?

ABSORPTION, TRANSMISSION AND RADIATION OF HEAT.

9. § 30. The power of absorbing heat is in direct proportion to the power of emission.

10. Heat, too, plays an important role in air movements in the soil. The diurnal variation of temperature in the soil becomes less as the depth increases, and the point at which that

*For the benefit of the common reader, a general outline of the mode in which heat is imparted to solids, liquids and gases is given; also, the manner in which they impart it.

variation disappears changes with the capacity of the ground for conducting heat, and with the season.—[Quintelet—Prof. Forbes.] The cold of winter and the heat of summer become imperceptible, at the depth of forty or fifty feet, and neutralize each other. The sun's heat in summer, however, penetrates the earth by induction, to the depth of forty to ninety feet, depending on the moisture, the looseness or compactness of the soil.

11. While the sun remains above the horizon, the heat radiated by the surface of the earth into space, is compensated by the absorption of solar beams, but when the sun sets, and this supply ceases while the emission of heat goes on, the surface becomes cooler, until its temperature sinks below that of the air. The air in contact with the earth, of course, participates in the reduction of temperature; the aqueous vapor present speedily reaches its point of maximum density and begins to deposit moisture, whose quantity will depend upon the proportion of vapor in the atmosphere, and on the extent to which the cooling process has been carried.

12. § 31. In a clear, calm night succeeding a hot day, dew is formed abundantly, when the air is holding a quantity of vapor. Simultaneously, radiation is progressing with equal rapidity. Now, if a thermometer be placed on the surface of the soil and another a few yards above it, the latter may indicate 10°, 15°, 20°, or even 40° Far., above the former, and frost may be present, but the radiating surface of the earth has not been cooled to any considerable depth.

13. § 32. "When the air in any locality acquires a higher temperature, or a higher dew point than that of the surrounding regions, it is specifically lighter, and will ascend. In ascending, it comes under less pressure and expands. In expanding from diminished pressure, it grows colder about one and a quarter degrees for every hundred yards of ascent. In cooling as low as the dew point, it will begin to condense its vapor into cloud" (Espy), and evolve latent caloric. This evolution of latent heat will prevent the atmosphere from cooling so fast in its further ascent, and will also assist in keeping the ascending volume warmer than the atmosphere around it. Where does this ascending volume of air go, and whence comes the cold air to take its place? They are not left to "chance," we may rely upon it, but they are guided by laws that compel all parts, functions and movements of nature's machinery, to move in harmony.—[§ 4, 15.]

RESIDENCES MOVED FROM SICKLY TO HEALTHY LOCALITIES, BY MY ADVICE, IN ACCORDANCE WITH THESE DISCOVERIES.

1. § 33. W. J. Ford's residence, marked No. 1 [see map], situated seventy feet above the river on dry table land, on the west half of southwest quarter of Section 9, Township 27, Range 6 east, near a deep hollow running northward from the Wabash River. From the canal, the lime rock had been worn away to a

depth of thirty to forty feet, up to the road in front of his house. Here, the hollow ended, and the brook ran over the rock's surface. At this point, a fine spring of pure cold water ran out from under the rocks, which, probably, induced the owner to locate his residence here. This house was occupied from the spring of 1840 to 1844. Aside from the river bottoms, there were no sources of malaria near it. During this interval of four years, this family suffered greatly from bilious attacks, from ague, and from fevers. Three children died here. The suffering, the loss of time and the expenses, taken in connection with the hardships of a new country, were too great to be endured long. I was his family physician and his brother. My sympathies were greatly excited in his behalf, not only on account of our relationship, but I had induced him to move from Alton, Ill., to Wabash, on a promise that I would leave Connersville, Ind., and come here also, that we might spend our days together.

I had now discovered the laws governing local currents of air and had had one year's experience in (theoretically) comparing their movements about houses in healthy and sickly places. I was so thoroughly convinced that these theories were true that I advised my brother to build a new house [No. 2, see map] sixty-five rods west of the one he occupied. This site was on ground thirty feet higher, and one-fourth of a mile from the Wabash River, but the lime rock was within four feet of the surface of the earth. A well was blasted out thirty feet deep and a plentiful supply of water obtained; a new frame house was finished and his family occupied it before the next sickly season arrived. This fall (1845) passed, with the exception of a short attack of colic, without sickness. The family lived in this property a number of years and had no sickness incident to the country, and up to this day, this is as healthy a location as is found in the Wabash Valley. The first house stood, up to 1855, and many families lived in it, every occupant during the autumn having more or less sickness of a zymotic character. The number of cases of disease in the first dwelling were so much greater than that of the new, the neighbors wanted to know how the writer knew that "that was a healthy place."

2. § 34. R. D. Helm, on Helm's Creek, in Section 9, lived at No. 1, on Map. Another house stood at No. 3, occupied by a renter. H.'s family consisted of six persons. They were severely afflicted by sickness each fall, winter and spring. His physician's bill ranged from $75 to $100 each year. The second year he lived on this farm, two of the renter's children died. This was in 1845. He had heard that the writer was an "expert" in selecting a healthy location for a dwelling place. He came to me and said: "I am in great distress. I fear we are all going to die off at my house. I want you to select a healthy location for me to build a house upon, and if there is none I shall leave the country." His importunity was not to be thrust aside. I went with him. The creek had worn away the rock, forming a valley

200 feet wide by 35 deep, with perpendicular walls, up to Helm's house, but from here up the stream ran above the rock. The house stood in line with the axis of the valley. Here, a strong, cool spring flowed out from a crevice in the rocks. This location with its environment, was very analagous to W. J. Ford's, described above. At the close of this day, the air was still, the night was clear and the moon was full. We set some stumps on fire on each side of the creek. By these, we could at once tell by the smoke, which way the air was moving. Presently, the air current drew into the valley and down it, toward the river. This continued until near 11 o'clock P. M., when the atmosphere was still; but, in a few minutes, the smoke flared to the north and the current was changed. In a short time, the odor from the decomposing animal and vegetable matter from the bed of the river was perceptible in the air. Shortly after this, the river valley had reached the dew point and the black fog was seen at a distance streaking up the creek. It covered both houses, barn and orchard. Everything was submerged but a low hill on the opposite side of the stream, eighteen rods west of house No. 1. As the night advanced, the fog spread out laterally and covered this level table land, I know not how far, but it did not cover the hill. The moon shone brightly all night and the noxious odor was not perceived.

These observations were kept up for several nights, at intervals. Vanes were used four feet long, suspended on fine silk thread and were very sensitive to air movements. During one particular night, the dew point was not reached, because the radiation of heat from the river valley was reflected back by clouds. These fog movements cannot be depended upon to settle these important questions; but if the temperature sinks early in the morning to the dew point, the fog is commensurate with the moving volume of air and shows accurately its length and breadth. Its margins are as well defined as those of the Gulf Stream and can be accurately traced by the eye. When fogs occur, however, they are of great value, for they settle, not only the boundaries of air-currents, but they indicate the condition of the soil over which they pass.

Mr. Helm was present when these experiments and observations were made. He was so thoroughly convinced of their correctness and truth that he immediately contracted with A. D. Meas to make and burn a kiln of brick for a new house to be located on the hill before described. This house was finished and he moved into it. A new bank barn with stone basement, and outbuildings were constructed at great expense—on "faith alone," in my teaching. My faith had been confirmed before, by demonstration; hence, I did not feel much responsibility.

What was the result of this change of location?

The answer is brief. His medical bill the first year after the change, was $9.68; the second year, $5.37. Subsequently, Helm sold his farm to Gen. John B. Rose. Rose's medical bill,

the first year for a family of seven persons was $7; the second year, $3.25. The experience of these four years convinced me that my scientific discoveries were at open war with my pecuniary interest, but the gratification and the knowledge of having achieved a discovery of real value to our fellow-man were of more value to me than money.

§ 35. Close to Helm's first residence was a large orchard. It was a noted fact that, when the fruit was destroyed by frost or freezing throughout the neighborhood, this orchard was heavily laden with fruit; that, "when others failed, it hit"—making it very profitable to the owner. This result was obtained by the heated air and fog from the river bottom being transported into it, thus keeping away the late autumnal frosts until the young wood was fully matured and the fruit buds perfected and able to stand any degree of cold occurring in this climate. In the spring season, also, the late frosts were prevented from injuring it by the warm air-currents described above.

It may be stated in this connection that the locality proper for vineyards, gardens, and early and late vegetables, may be determined in the same manner that you would fix a place for a dwelling house, with this difference, however; you would locate the vineyard, orchard, or garden, where the heated air *did* accumulate, and your house where it *did not*. It is true, this would separate them, but no intelligent man would expose to danger the health of himself and family by placing his dwelling in a suitable site for these conveniences.

3. § 36. S. Mason settled at No. 1, on the east half of the northeast quarter of Section 9 (plate II), on the north bank of Helm's Creek. Here this family were all sick. Mr. and Mrs. Mason had each a severe attack of typhoid fever, lasting six weeks. This occurred in the fall of the year 1850. It was evident the family could not live here, and another site was selected where his house now stands, at No. 2. At the time this location was made, the land was covered by a dense forest, by bushes, nettles and other weeds, and it was difficult to get through them; but its topography was learned and this selection made. Very little sickness incident to the country occurred here. After the children grew up to be men and women, one boy died from the operation of lithotomy, two girls from consumption (hereditary) and the father from heart disease; but these diseases may and do occur in any locality.

The application of these laws governing currents of air has been practical in selecting healthy sites for dwellings, and three examples are given in sufficient detail to enable the reader, with statements given above, to understand how it is done. These are deemed sufficient. In the map where the figures 1 and 2 are placed, they indicate a change in accordance with the rules before given.

AIR MOVEMENTS ON LEVEL LANDS.

§ 37. Large tracts of country, many miles in extent, are

found—some treeless, some covered with timber. To the eye of the observer they appear level, yet they have their trends and systems of water-courses; and, in many of them, the surface drainage is almost perfect; in others, a string of ponds or swamps may be found and the surface generally wet. No person in his senses would attempt to live in such a location as this, not even after it had been thoroughly drained and cultivated for four or five years; not till the sun's rays and the surrounding elements had wrought such chemical and mechanical changes in its surface as would destroy the development of the germs of disease; but, in the former, healthy localities may be found as easily as in any other place.

§ 38. Another factor in explanation of these subjects must be considered here; it is the "water-level," or line of saturation in the earth. It forms a distinct boundary between the underlying saturated soil and the ground above it, which contains water and air in variable quantities. (§ 10).

The heat of the sun's rays does not penetrate the soil below the water level. If this be near the surface, the ground is cold and wet, and all the conditions for the development of malaria are present. To live upon such soil, you may depend upon it, is to endanger health and life. In newly settled countries, as the timber is cut away, the water-courses are cleared out and deepened, the water level sinks, new wells have been constructed or old ones sunk deeper, springs and brooks dry up, the hatching ponds for musquitoes and fogs disappear. These changes may cause some inconvenience and loss, but they should be regarded as the harbingers of a better sanitary condition of the country.

§ 39. "There is a great difference in soils with respect to their power to absorb and retain moisture. Scarcely any are without it, and some possess the property to a very remarkable extent."—[A. H. Buck]. Soils absorb heat in proportion to their looseness or compactness, but chiefly by their dryness or dampness. Dry soils may absorb heat downward by conduction (§ 4) from 40 to 90 feet during the summer season, but soil that is very damp, almost to saturation, absorbs heat very sparingly, for this reason: The particles of earth are fixed and almost surrounded by water and cannot readily transmit heat downward. On the other hand, heat by convection (§ 5) cannot descend, for the particles of water at the top are lighter than those below, and hence have no power to descend. Evaporation, too, carries off a large per cent of heat, consequently these lands, as compared with dry, are always cool, damp and unhealthy. Having finished these explanations, we return to the discussion of air movements.

§ 40. After the sun sets—in a clear, still night—radiation of heat progresses equally on both wet and dry soils, as before explained. As the wet surface has but little heat to radiate, its temperature is soon reduced to the dew point, or till frost falls, the air is heavy and cold, but the dry land and the air above it

are comparatively warm; the warm volume of air being lighter, ascends; at the same time, the denser volume of atmosphere over the wet land under-runs it and takes its place on the dry land. Thus the warm and cool air continue to change places until an equilibrium in temperature is formed and the upper downward current reverses it. [See Plate 1, § 27, 28, 29.] On prairies, these air movements, like the sea and land breezes, may extend over many miles, and are governed by the same forces and in the same way as those that take place among the hills and valleys.

PECULIAR AIR MOVEMENTS.

§ 41. The valley of Treaty Creek one mile above its mouth, is nearly fifty feet above the bed of the Wabash River, the space between the hills on either side is seventy feet deep and 300 feet wide. From this point, the ravine rapidly increases in depth to 100 feet and in width to 1,000 feet. Near its mouth, it turns eastward and strikes the axis of the Wabash River Valley at an angle of 80°. Again, the hills on the north side of the river fall back on the line of this angle, forming a pocket; this gives great width of bottom. Now, let the cool, dense air move down the creek at the rate of two or three miles an hour, and impinge against the warm air in the river bottom moving eastward with the same velocity, the direction of both currents is changed, but the cooler forces the warmer air around this *cul de sac* and upon the hills west of it, carrying the fog and malaria with it, thus distributing the germs of disease in a locality otherwise healthy, on the hills and highlands for miles around. No swamp or stagnant water exists here, and all the conditions for the development of miasma, except the bed of the river itself, were wanting.

Before the timber was cut away, the same diseases obtained that do now. The people call this a "Poison Point." This idea was borrowed from the Miami Indians, who offered tobacco on a huge bowlder here to propitiate the "Great Spirit" for fear the evil genii would afflict them. The altar is gone, the offering has failed and the donor has entered the "happy hunting ground," but the genii are at their post yet, demanding their victims.

§ 42. Another peculiarity of these side movements is shown in a narrow, deep ravine east of the old cemetary running northward. The pressure made against the air current ascending the river by that passing down Treaty Creek, forces the air up this ravine on the high lands northeast of the city. These lands, though 100 feet above the river, are naturally damp and lose their heat early in the evening. On these the fog from the river bottom rolls up the valley, and crosses them about 11 o'clock P. M., and it frequently runs over into the valley of Charley's Creek. This locality for the past forty-three years has had more deaths and more sickness of a grave type, in proportion to the number of inhabitants occupying it, than any place within the

radius of five miles from the city of Wabash. Within the last few years, the number of cases of disease in this locality has greatly diminished, especially intermitting fevers, but the graver types, such as rheumatism, consumption, enteric and typhoid fevers, still continue.

The question may be asked why cool and hot volumes of air do not mix and equalize their temperature by this method. The answer to this question is not fully settled. Oxygen is a magnetic substance, but nitrogen is dia-magnetic. These two gases when mixed, twenty measures of the first to seventy-nine of the last, form our atmosphere. The difference in density of warm and cool volumes of air may change their magnetic condition. At any rate, they do not mix in nature's laboratory in this way, as is illustrated on a grand scale by the movements of the trade winds.

PATHOTOPIA.*

WHERE NOT TO BUILD A HOUSE.

§ 43. In selecting a site for a dwelling house, shun ground in which the water level is high and the soil is wet or very damp, and in which there may be a large amount of humus or decaying animal or vegetable matter, and where thorough drainage cannot be obtained. Test the water supply first. If much vegetable or animal matter is found in it, select another site. Mists and fogs are always unhealthy. Never locate at the mouth of a valley that empties into a larger one, nor upon its banks if the fogs settle there. These valleys act as venti-ducts or chimneys to carry air loaded with moisture and the germs of disease to the high lands along the banks for great distances. If the prevailing winds pass over marshy lands or water where mists or fogs abound, avoid their track. Avoid damp, dark valleys and low places surrounded by hills; avoid locations where the air passing up running streams, will strike the residence. In mountainous countries, shun places where the cold winds, after a hot day, run down their slopes and cover the dwelling. The variation in temperature in winter on slopes facing to the northwest is too great for health and comfort, if it can be avoided. Neither the top nor the bottom of high hills is eligible for a dwelling place; the former is too changeable, the latter too damp.

§ 44. Houses should not be erected on what is called "made-up-ground," unless thoroughly under-drained before the fill is made, especially, if it was a hollow through which the water flowed after wet spells. Rains and melting snow fill the interstices of the ground for many feet beneath its surface. This water percolates through the earth into these hollows, and carries out particle by particle of the finer constituents of the soil until a natural conduit or water way is formed; through this, the land above is relieved of its surplus water, so far as the trend is in this direction. The places are usually filled up with ashes,

*From *Pathos*, disease, and *Topos*, locality.

street cleanings, dirt from cellars, and every variety of garbage from the town or city. When this ground is filled with water, the natural outlet being blocked up, the hydraulic pressure above forces this water through the interstices of the made-up ground, carrying out its carbonic acid and other noxious gases, filling the air in its locality with dampness and malaria. These are dangerous locations and should never be occupied by living beings, until thoroughly drained below the filling. I will venture the opinion that such places may be traced out in cities to-day which have not been completely under-drained, by the cases of sickness that occur alone. These negative observations are written for the rural population; in cities and towns, it is only the privileged few who have the advantage of selecting sites for new houses.

HYGETOPIA.*

WHERE TO BUILD A HOUSE.

§ 45. Select an elevated situation where the water is pure, where it does not rise and fall by accessions of surface water after hard rains, and where its level does not range above fifteen feet below the surface; where the drainage is or may be made perfect; where the air is fine and pure and not contaminated by emanations from the soil; where the sun's rays are not obstructed by high hills or forest trees. Fear not his rays, for by them all animated nature lives, moves and grows. Select a soil, if possible, not too retentive of moisture; but a dry, gravelly, sandy loam or limestone formation, compact clay or clay with gravel, and a low water level with thorough drainage, makes a commendable site. A bench, part way up a hill, not near a break or a hollow in it, facing the southeast, south or southwest, other things being equal, makes a very pleasant place for a dwelling house on such formations.

§ 46. On level lands, it is needful to proceed with more circumspection. It is necessary, not only to make accurate observations on air currents, but the thermometer must be used to settle these important questions. Dig or bore down from one to three feet, in several places, on dry as well as damp grounds; take the temperature at the bottom and top of all the excavations, and then compare them. The soil that will carry the largest amount of heat the lowest down, in a given time, is, in the main, the dryest. A soil that will not conduct the sun's heat downward is unfit to live upon, it is too damp or too wet.

OTHER FACTS ILLUSTRATIVE OF AIR CURRENTS.

§ 47. Late in the fall of 1862, the Army of the Southwest camped near the town of Patterson, Reynolds County, Mo., on a plateau with hills south and north of it. The smoke from our camp fires divided in the middle and ascended these hills. The fall rains had commenced and the camp was muddy, but the

*Hygetopia, a healthy locality. From *Hygieia*, healthy, and *topos*, place.

nights were cold and the mud was frozen—when it was not deep—hard enough to bear a horse: yet, on these hills, tender vegetation was green and gave no signs of frost. By 11 o'clock each night the sky overhead was clear, but the hills were covered by a canopy of smoke.

§ 48. We were camped on Jack's Fork of Currant River, in Shannon County, Mo. Here all the native physicians had left with the Confederate army. It was in the fall of the year. The country was mountainous, with scanty vegetation, dry and barren, but the people were sick without any apparent cause. Their diseases were of a grave type. The prominent features were these: Mind sluggish, skin cool and clammy, pulse too slow and weak, tongue heavily coated and brown in the middle, breath foul, some enlargement in the region of the liver, tenderness over the head of the colon, and vitality low. The system seemed to be overwhelmed by some narcotic poison. No re-action took place, the patient died. When asked for a cause of this sickness in the sterile region, the people said: "In the fall, when the winds come from Black River Swamps a great many people get sick and die; the doctors can't do much for it." "How far are these swamps from here?" "Fourteen miles." "How do you know it comes from these swamps?" With a look of surprise, the answer came: "Why, can't you smell the cypress?" Sure enough, the odor of cypress was in the air. Cypress grew in the swamps of Black River, but not on Currant River. This case is cited to show how far miasma may be carried by air currents, and to warn persons intending to locate sites for houses, towns, or cities, not to place them in the line of prevalent winds that pass over swamps, though many miles away.

§ 49. Surely the founders of "Washington City" knew nothing about hygiene, or they would not have located it at a bend of the river, where the atmosphere, passing up the Potomac, sweeps through a large portion of the city. There is, also, an almost irreclaimable swamp adding its pestilential germs to the already contaminated breezes that pass over it. The White House is in the line of these insalubrious air currents and should not be occupied by the "Nation's Chief," during the sickly season (§ 25).

§ 50. These air movements have been seen a great many times in the Wabash Valley, when the people were clearing the land and burning the brush and logs on it, the smoke from the burning timber ascending upon the hills on each side of the river. These phenomena did not always occur. If wind or a moderate breeze came from the south or southwest, the heat and smoke were wafted to the north or northwest. It was further observed that when the clouds ran low in the evening and the air was still in the valley, these revolving air currents (§ 4, 5) did not occur, but the valley cooled by radiation down to the dew point, and the fog filled it from hill-top to hill-top until the sun in the morning resolved it into air. In this case the wind

was too near the earth for the descending current to move with sufficient force to set in motion the elements below. These phenomena occasionally occur, also of clear nights, probably from the same cause.

I failed to mention another factor connected with these revolving air currents or machine, if I may be allowed to use the name, described more or less through these pages: it is this: This machine, without disturbing any other motion or movement, travels up the Wabash Valley at the rate of two or three miles an hour, and for the space of forty years I never saw it move in an opposite direction.

AIR CURRENTS IN THE EARTH.

§ 51. This treatise would be imperfect without a description of "ground air-movements."

"The atmosphere penetrates the earth and circulates beneath its surface to an indefinite depth."—[William Ford]. To the scientist, to say nothing of the scientific agriculturist, this is a very important study, involving (1) a "knowledge of the constitution of soil; (2), pollution of soil; (3), and diseases induced by conditions of soil." The study of the constituents of the soil belongs to the domain of chemistry, and cannot be described in this article only so far as it has a direct bearing on sanitation through the medium of ground air and pollution of soil.

§ 52. What is understood by soil in the following sketch consists of clay, sand and gravel intermingled with animal and vegetable substances, including water, ammonia and several gases, not including rock formations, but such as are used for agricultural purposes, wet lands and swamps. The air circulates through the ground down to the water level (§ 39).

The amount of air in the soil is apt to be under-estimated. "Loose sand and gravel contains fifty per cent; moderately pulverized soil twenty-five per cent, and loose soil turned up for agricultural purposes may contain from two to ten times its volume of air."—[Parks]. Gases usually found in the soil will be mentioned in the order in which they are found in the greatest quantity, namely, nitrogen, oxygen, carbonic acid gas and hydrogen. All of these gases when taken into the system of man in moderate quantities produce no deleterious effect, but carbonic acid gas breathed into the lungs is a deadly poison. It is what is known as well-damp. Any locality where this gas is extensively generated in the soil is regarded as unhealthy. The forces that act on the air in the earth are winds that pass over it, heat by expansion, cold by contraction, rains and melting snows.

§ 53. Air being 770 times lighter than water can go where it can go. Bear this statement in mind and reflect upon it. Pettenkofer has demonstrated the facility with which air passes through compact soils, through brick, through mortar and through plastered walls. Example—A leak sprung in a gas pipe under one of our streets a few days ago. The gas passed

from it through the soil a distance of 600 feet and filled a citizen's cellar, well and cistern. The leak was stopped and the nuisance disappeared. Let the wind move briskly in the line of a tile drain, twenty rods long and laid four feet deep with the windward end closed. Then the wind will rush out of the open end strong enough to put out a light or move light bodies. In this case the superincumbent air, by its pressure on the surface of the ground forces the air below the soil in the same direction. Hibernating animals could not live in the earth if the air did not circulate through it. In the winter season, the earth cools down to about 41° Fah. below the frozen crust, and its interstices are filed with cold, dense air. In the summer season, it is heated down forty to ninty feet by the sun's rays. This dense air expands by heat and rushes out, carrying with it all the gases and germs of disease that may have been generated in it through the winter. Thus it inhales to repletion in winter and exhales in summer, yet it has a diurnal respiration, caused by the same force and in the same manner but in less degree [§ 39].

§ 54. Rains and melting snows fill the earth's surface with water, and, unless they fall in great abundance, the earth is not filled with them down to the water level [§ 38]; then, as the water sinks by its own weight, the air below is forced out, and that above followed by its own gravity. Every heavy shower repeats this movement in the soil.

§ 55. Rain-water, though almost pure, contains a small per cent of ammonia and carbonic acid, but when it strikes in the earth it dissolves out, from decaying substances on the earth's surface, an amount of animal and vegetable matter, which it carries down with it. It is upon these extracted matters that aquatic insects live; their presence is a sure indication of contamination. This water is not potable — it pollutes the air above it.

§ 56. It is an acknowledged fact that a tile drain, well laid, four feet deep, will carry off water from a strip of ground fifty feet wide on each side of it. Now suppose the house well be fifty feet deep, the water trend would be, on all sides, 300 feet—600 in diameter. The dwelling house is always near it, and on farms, the cattle yard, the stable, the hog-pen, and above all that most abominable and unmanagable of all nuisances—the privy—are within 100 to 200 feet of the well and house. And, suppose further, that the soil around the building is polluted by slops and garbage from the kitchen, in what condition would you expect to find the water in the well, and the air in the ground around it? *Polluted, of course. The former unfit to drink; the latter unfit to breathe.* This is not an overdrawn picture. I have said nothing about the condition of the cellar, about ventilation, and about poisonous gases, from sources indicated above. Air and water are grouped together here, because the water carries the filth into the earth and contaminates the air above it.

§ 57. In cold weather, when the dwelling is heated, the air

inside being lighter than that under it, runs up through the floors and around the walls. This movement is caused by the pressure of the cold atmosphere outside forcing the ground air under the walls of the house to take the place of the air inside. These air movements continue as long as the heat is kept up inside. The reader should recollect that if the water level is high, the air coming in from below will be loaded with moisture, and all textile fabrics may be damp and moldy [§ 32.]

§ 58. *Dampness* is the exciting cause of colds, bronchitis, rheumatism, consumption, and, doubtless, many other diseases. *Polluted air and water* give rise to a large class of maladies known as "filth diseases," too numerous to name, but typhoid fever and diphtheria are specimens of them [§ 38.]

The mass of the people know little or nothing about the first principles of hygiene. To them it is a sealed book; they have no means of gaining knowledge in this direction. Physicians, as a body, are not learned in this science, and are too busy to impart knowledge to their patrons. The daily and weekly press have adequate facilities for disseminating this kind of knowledge among the people; but they, too, like the physicians, are not skilled in this department of science. These pages are written to remedy this defect, so far as they go, and to impart some knowledge of air movements not before known. If any person is disposed to object to or criticise any statement made by me, in these pages, I hope he will do me the honor, not only to show wherein I am in error, but give me the truth, or, at least, something better in the place of it—"*Save the wheat but burn the darnel.*"